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REVIEWS.

SOME RECENT ALPINE STUDIES.

Beiträge zur Lehre von der Regionalmetamorphose. L. MILCH (Neues Jahrbuch für Mineralogie u.s.w., Beilage Band IX., 1894).

Zur Classification der unorganogenen Gesteine. L. MILCH (same journal).

Études dans les Alpes Francaises. MARCEL BERTRAND (Paris, 1894).

Through the classic works of Heim and Lehman in 1878 and 1884, the problems of metamorphism were clearly set forth and attention was called to the fact that nowhere in the world were the conditions more favorable for their solution than in the Alps. In this region all gradations were to be found from the least metamorphosed sediments to the most highly altered clastics and eruptives. Investigators of marked ability were attracted to the field and a very copious literature on Alpine metamorphism has resulted. Their success led to similar work in numerous other fields where these same problems had been considered as incapable of solution. These workers look with interest to all contributions to the knowledge of Alpine geology, for they are sure to contain valuable suggestions for the prosecution of work on the crystalline schists the world over.

During the past few months Dr. Milch of Breslau has published a second paper on the dynamic phenomena of the Verrucano. In a former paper[1] he discussed the subject of the dynamic metamorphism of the eruptive rocks, and in the present paper he gives some results of a study of the metamorphism of the sediments as bearing on the general subject of regional metamorphism.

Many of these altered sediments show typical clastic grains, while others have lost all trace of such character. Such rocks are divided according to the nature of the alteration into the following groups :

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[1] Reviewed in JOURNAL OF GEOLOGY, Vol. I., No. 8, p. 850.

I. a. *Allothimorphic fragments*, with the composition and form of unaltered clastic constituents.
  b. *Authimorphic fragments*, with the composition of the clastic constituents unchanged, but the form altered.

II. a. *Allothimorphic pseudomorphs*, with the composition changed in a manner depending on the nature of the former substance, but with unchanged form; dependent new products with old allothimorphic form.
  b. *Authimorphic pseudomorphs*, with the composition changed as above, but with altered form; dependent new products formed with new, authimorphic form.

III. *Eleutheromorphic new products*, with composition and form altered; true authimorphic products.

Under the division of authimorphic fragments two classes are distinguished; those which have become adapted to the altered conditions are designated as *kamptomorphic;* the others are called *authiclastic.* All of the categories above tabulated are observed in the rocks of the Murgthal. The first and second divisions are observed especially in the quartz, feldspar, and mica, while the third is best seen in the sericite and iron hydroxide masses. In the latter case, there is a varied arrangement of the leaves and fibres. Where the new products are radically arranged around the larger minerals, the structure is designated as *eleutheromorphic-lenticular* (flaserig). If these new formations wind around the larger mineral components, the structure is called *mechanical-lenticular* (flaserig). In the first case, the single leaves are not deformed and they show no optical disturbance, while in the second instance these leaves are bent. The former are analogous to the links of a twisted chain, and the latter to the strands of a cable.

The author compares with the altered sandstones of the Murgthal, the curved lenticular gneiss of the Rhine valley. These rocks have been strongly contrasted by all previous students, but Dr. Milch regards the difference between them as one of degree rather then kind. In both the original unaltered material was allothimorphic. The present authimorphism has been produced by chemical and mechanical means. The cause has usually been regarded as pressure alone. This explains the mechanical alteration of the components, but the chemical alteration is only to be explained by a transfer of substance through the agency of water. Dislocation and faulting are not necessary to produce these changes, for pressure and high temperature are sufficient.

In a discussion of regional metamorphism two divisions must be recognized, *pressure* and *dislocation* (dynamic) metamorphism. The former alters all rocks, while the latter is dependent on the nature of the rocks, and it is confined to certain areas. Both build similar minerals and they have a common cause for mineral alteration. The tests for distinguishing regionally metamorphosed rocks are varied. While Credner and Dathe emphasized the point of the presence or absence of mechanical phenomena as the clue, Milch regards the absence of such effects as no proof against dynamic metamorphism. A second distinction is the entrance of magnesian minerals of the mica and chlorite groups. In regionally metamorphosed rocks chlorite is more important, while in the true crystalline schists biotite is the important mineral.

Clastic structures are often lost and so cause an outward resemblance of many gneisses to eruptive rocks, but that this is only external is easily proven by the chemical composition.

In pressure metamorphism, the pressure is at first weak but increases slowly through the successive geological periods, and it produces especially kamptomorphous forms. The condition for dislocation metamorphism is a sudden pressure working in a limited time with varying intensity and direction. This pressure does not form gneisses but mica schists. In a rock under a slight pressure, clastic phenomena are abundant, but as this pressure is increased, the forms become kamptomorphous. Finally, with great loading and small motion, gneisses are formed resembling those produced by pressure metamorphism. Thus the two divisions are bound together by numerous transitions. The great force is pressure which sometimes produces greater mechanical changes, under other conditions, more chemical alterations. Mechanical changes, especially the crushing and formation of small components, characterize dislocation (dynamic) metamorphism.

Dr. Milch, in the second article, presents a new rock classification which depends essentially on the source of the material of the rock constituents and the cause of their present form. It is fourfold and conformable to the four divisions of igneous rocks, chemical precipitates, mechanical sediments, and crystalline schists. Its advantage over this old system is the placing of the products of contact and regional metamorphism in a fixed placë.

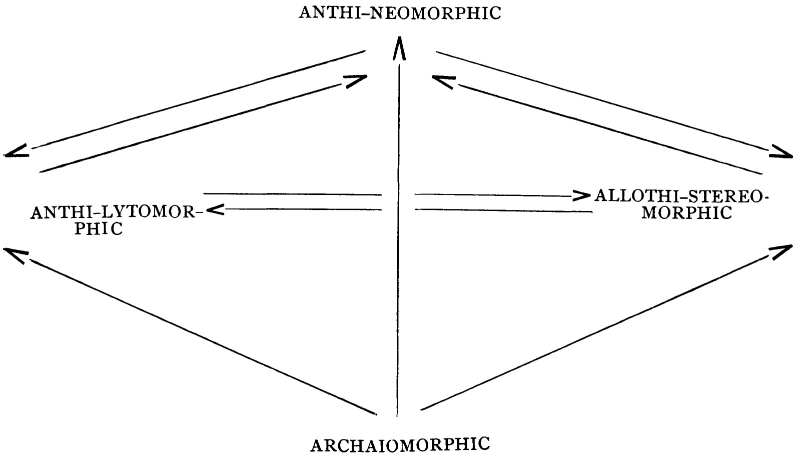
Group 1) includes rocks composed of components whose material separated out of the original molten sea, in the form of the present rock. Such types are called *archaiomorphic*. To this group belong all the eruptive rocks. Through alteration, transport, and reconsolidation new groups are formed, known as *neomorphic*, which are further divided according to the manner and condition in which the material has been transported, and the way in which the constituents have acquired their present form. There are three groups of these neomorphic rocks.

Group 2) includes rocks whose material was in another form and in another part of the earth's crust, but the form of whose constituents has been acquired without outside influence. These are the chemical precipitates and are designated as *authi-lytomorphic*.

Group 3) includes rocks which originated in another place but through transportation have been brought in a solid condition to the present location and united into a new rock with the old form. These are the mechanical sediments, and they are called *allothi-stereomorphic*.

Group 4) includes rocks composed of constituents whose material was originally deposited on the place where they are now found, but which have in a mechanical or chemical manner built a new rock on the old place. Here are placed the products of contact and regional metamorphism and weathering, and they are designated as *authi-neomorphic*.

Each of these three neomorphic divisions under altered conditions passes over into the other two, but all originate from the first division, or archaiomorphic. The various possibilities are shown in the directions of the arrows in the following diagram given by Dr. Milch:



Professor Bertrand has extended the work to the westward, and brings together in two papers the results of his four years' work in the French Alps. The first paper describes the structure and metamorphism, while the second is devoted to a discussion of the *lustrous schists*.

The structure is that of the fan with the folds on the west dipping toward France and on the east toward Italy. In the neighborhood of St. Maurice and Briancon, the axis of the fan is formed of Carboniferous rocks; while farther south, it is formed of Eocene layers inclining in the same way. While the Carboniferous zone on its western border forms a curve regular and parallel to the axis of the chain, the interior folds are remarkable for their irregularities. The cause of this difference is the presence of elongated lenses occurring in the synclines and anticlines. Such an arrangement resembles the augen (amygdaloidal) gneiss, so the name *amygdaloidal* (augen) *structure* is proposed. To illustrate the importance of these lenses, Mt. Blanc is found to be one large lens or augen rising from a synclinal area.

All this region of the Alps during Carboniferous, Triassic, and probably Jurassic time has been the seat of continuous sedimentation. The later movements have restored to light these ancient sediments and have shown the depths to which they have been buried.

While in one case the lustrous schists seemed to be of Palæozoic age, in all other places they are better interpreted as Triassic. The very great development of green rocks of apparently Triassic age seemed exceptional, but they were found in other places associated with fossils. The author regards the Hudson river group in the United States, as described by Walcott, as the first instance comparable to these lustrous schists. Similar bodies of schistose rocks as a facies of fossiliferous beds occur in Scandinavia and the Pyrenees. It is, then, a general fact that on the site of the important mountain chains, before their formation was complete, there was active sedimentation with a schistose facies limited to the synclines and usually of basic rocks. In this region there was a rapid filling up of the geosynclines in the flysch periods. The Triassic *flysch* was formed at the centre of the chain before the first submergence. The Eocene *flysch* was deposited on the border of the chain already emerged, and this was followed by active denudation which resulted in a recent rupture of the equilibrium. That the age of these lustrous schists is Triassic there is but little doubt, a conclusion which agrees with the observations of Lory.

G. PERRY GRIMSLEY.